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ABSTRACT

Project Kaleidoscope (PKAL) focuses on transforming undergraduate science, mathematics, engineering, and technology programs and draws faculty from across disciplinary lines. The project report provides an overview of the project; a section that traces the project from problem definition to project conclusion and discusses administrative pitfalls; details on the background and origins of the project categorized by phases with a focus on organization, policies, and funding; a full description of the project and its workshops, colloquia, consultant program, publications, and faculty; and an evaluation and project results organized into national and local sections. (DDR)

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COVER SHEET

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c/o The Independent Colleges Office
1730 Rhode Island Ave. N.W. #803
Washington, DC 20036

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Appendix: INFORMATION FOR FIPSE

(1) Forms of assistance: The initial and continuing support from FIPSE program officers and the FIPSE director were invaluable to our work–at all stages. In the process of developing the initial proposal, which was submitted in tandem to both NSF and FIPSE, we received good advice and counsel, and several potential 'red flags' were identified and addressed in the process of developing and articulating the plan for PKAL. Given the decrease in staff because of funding cuts, it may be that FIPSE should develop a structure (and perhaps a template) for mentoring that would link potential grantees with current and past grantees. There could possibly be 'training' sessions for such mentoring at the annual FIPSE project directors meeting. Obviously, if and when a grant is awarded, there will be questions and issues that must be answered by professional staff.

(2) New directions: Answering the questions *"to whom will your project make a difference and how will they know"* should be central to funding decisions in the coming years. If the impact of federal grants on the process of reforming postsecondary education is to continue to be positive, connections and 'ripple-effect' activities should be built into all projects. In some cases, this could mean local connections, in others it could mean connections to peer institutions and/or those in other sectors of the higher education, industry, or the K-12 communities. Recognizing that projects focused solely on assessment and studies are not the main purview of FIPSE, it still seems FIPSE could facilitate the documentation at the national level that 'discovery-based' (research-rich) environments do in fact improve learning for all students in science/mathematics/engineering. Given that comment, I am still concerned that the decrease in funding levels and the current national emphasis on comprehensive reform (particularly at NSF) could mean that embryonic ideas for a new approach (an idea that might have a small price tag initially and that might not pan out) would be less attractive to funding agencies–this would not be good. Also (not in any priority order), figuring out how to keep ahead of emerging technologies so that they truly become tools for the use of students and faculty–rather than an end in themselves. Finally, the issue of science for all students (not just for the self-selected major) is a critical one that must be addressed at the national level as we approach the 21st century.

(3) Other comments: In past years, at the end of ICO workshops on proposal writing, I always spoke about our commitment as a nation to building and sustaining a cadre of educated citizens well-equipped to live productive and self-fulfilled lives, and how tax dollars–awarded through federal programmatic agencies–served the national purpose toward that end. Somehow that commitment seems less visible now, and I seek to weave such issues into the PKAL dialogue over the next three years.

APPENDIX MATERIAL

Exhibits

Exhibit 1	List of PKAL Workshops and Participants
Exhibit 2	Summary of PKAL Homepage contents Summary of Web pages of curricular issues
Exhibit 3	Programs That Work
Exhibit 4	Workshop Related Materials - Workshop Template, Instructions to Workshop Leaders, Instructions to Host Sites, Workshop Evaluation Samples
Exhibit 5	Keck/PKAL Consultant Program
Exhibit 6	Dr. Seymour-Keck/PKAL Evaluation Materials
Exhibit 7	Letters of Support
Exhibit 8	Project Kaleidoscope Report, 1992-1996
Exhibit 9	Sample Institutional Report on PKAL Participation

Attachments

Attachment 1	Occasional Paper I: A Research-Rich Environment
Attachment 2	Occasional Paper II: What Works Leadership: Challenges for the Future

SUMMARY
PROJECT KALEIDOSCOPE

Project Kaleidoscope is an informal national alliance focused on transforming undergraduate programs in science/mathematics/engineering & technology. In PKAL meetings, faculty come together across disciplinary lines, from all sectors of higher education, with their administrative colleagues to explore what works in strong undergraduate science programs. From the forty workshops and meetings sponsored since 1992, PKAL has published two Occasional Papers, PKAL Volume III: Structures for Science and a Report on PKAL, and is developing an extensive presence on the PKAL Home Page (WWW). With the PKAL Faculty for the 21st Century Network, we are identifying and helping a new generation move into leadership positions in undergraduate SME&T.

Name: Jeanne L. Narum, Director
1730 Rhode Island Ave, NW, # 803
Washington, DC 20036
Report: PKAL Volume III

EXECUTIVE SUMMARY

PROJECT TITLE:	PROJECT KALEIDOSCOPE
GRANTEE ORGANIZATION:	1730 Rhode Island Ave. NW, #803 Washington DC 20036
PROJECT DIRECTOR:	Jeanne L. Narum, Director 202.232.1300 p00274@psilink.com

PROJECT OVERVIEW: The grant from the Fund for the Improvement of Postsecondary Education (U.S. Department of Education) to Project Kaleidoscope (PKAL) supported PKAL Phase II activities (1992-95). In this second phase, PKAL continued and built upon goals established at the beginning of PKAL Phase I, which are to be a catalyst for:

* reform at the local level, encouraging the strengthening of undergraduate science/mathematics programs across the country by focusing on *what works;* and
* a national dialogue, one which leads to a supportive environment in which local reforms can take root and flourish.

PURPOSE: The purpose of PKAL, from the very beginning, has been to identify isolated instances of success–productive innovations in SME&T programs that are emerging at the departmental and program level on single campuses–and to bring them to the attention of the larger community concerned about if/why&how to transform the learning environment for their undergraduate students. This isolation often meant that as reforms were being considered:

* few faculty, administrators, and others were comfortable with going outside their normal boundaries of responsibilities and commitments to explore new possibilities/solutions based on the experiences of others;
* although many strong and creative programs were being developed, to a large extent most were having little or no impact beyond the originating institution, department, or perhaps even beyond the instigating faculty member;
* there was no regular means by which information about successful reforms could be shared with and accessed by the broader academic community nation-wide;
* there was no common stock of ideas, or vision, about *what works* in undergraduate education–either at the local or the national level; and finally,
* there was too much focus on what was wrong, not enough on tested solutions.

Through a coordinated series of workshops, meetings, and publications, PKAL seeks to:

* build campus-based teams committed to and equipped for reform;
* shape public awareness about the relationship between a strong undergraduate SME&T community and our nation's leadership role in a world in which science and technology have an increasing impact on all life;
* join in partnerships with other organizations in the broad effort to transform

undergraduate programs in ways that serve the national interest; and

* evaluate and understand *what works* in advancing local reforms and in fostering a national dialogue.

BACKGROUND AND ORIGINS: Undergraduate SME&T in the early years of the 1980's has been described as "...stagnant, diminished in quality, dull and uninspiring...". At the time PKAL received its first grant from NSF in 1989, efforts to transform undergraduate SME&T programs were to emerging on individual campuses and funding agencies' new priorities were being felt across the nation. Connections between understanding how students learn best to new approaches shaping programs and spaces,as well as connecting the transformation of undergraduate programs to larger national issues (technology, under-represented groups, faculty careers, etc.)were being explored. However, in the midst of these transforming efforts, there continued to be what we in the leadership of PKAL thought was an unproductive focus on *what did not work* rather than ***what did work.***

During the first Phase of PKAL (1989-1991), the members of the PKAL leadership committee (all from liberal arts colleges) looked carefully at *what did work.* They studied successful undergraduate programs -- those on their own campuses and on other campuses across the country. They reflected on their personal experiences in classrooms, laboratories, and administrative offices, and identified the central principles that guide strong programs in science and mathematics in the nation's science-active liberal arts colleges. They documented existing practices and principles that seemed to characterize programs that were succeeding in attracting students to the study of science and mathematics, and that were ensuring their success in these fields.

PROJECT DESCRIPTION: Since 1992, when FIPSE support initiated PKAL Phase II, PKAL has sponsored forty workshops and meetings, in which over 2000 individuals from 500 colleges and universities in all parts of the country have participated. Collectively these workshops and meetings have addressed all facets of the undergraduate SME&T environment: faculty; curriculum; facilities; institutional and national issues. We believe what distinguishes our work from that of others is that we have indeed been kaleidoscopic. We sponsor, for example, workshops on facilities, because the kind of learning and teaching advocated by PKAL requires certain types of spaces (and existing spaces are inadequate on several counts). A program has been established for faculty at the early stages of their careers because we recognize that it is faculty who shape curriculum, and who must "own" reforms. We encourage administrative involvement because we are convinced that–to succeed over the long-term–reform must be a community effort. Finally, our work has been kaleidoscopic in that we have encouraged institutions to understand and relate to the larger context in which their individual efforts take place–to connect what happens on their campus to the world in which students will live and work.

Since 1992, in Phase II PKAL has received over $2 million in grants in support of a variety of programs. As outlined in the original proposal to FIPSE, these grants supported: a) a series of national and regional workshops on issues of broad interest and concern to the undergraduate community; b) partnerships with national associations; c) a consultant network; and d)

publications–print and electronic. These activities are at the core of PKAL Phase II; the creation of the PKAL Faculty for the 21st Century network brings a critical group to the PKAL effort.

EVALUATION/PROJECT RESULTS: Evaluation of the work of PKAL takes place on several levels: at the time of individual workshops/meetings; assessing the breadth and depth of the national dialogue about *what works* in undergraduate science; and determining what works in building and sustaining strong learning communities on individual campuses. The greatest challenge has been to monitor in a formal way the impact of PKAL participation at the local level. What we have done in this regard is to:

* send surveys out to a selected number of PKAL presidents, with follow-up surveys to some faculty and administrators on their campuses. These surveys gave us some base-line information about the presence of PKAL and the way PKAL information was being distributed and used;
* institute a regular series of questionnaires to secure information about institutional planning from institutions participating in PKAL facilities workshops. This information, which suggested changes in workshop format and direction for the development of Volume III, was gathered and analyzed by an evaluator supported by the NSF Facilities Workshop grant;
* have a selected number of institutional files analyzed by the evaluator of PKAL, as a major step in understanding how institutions are incorporating a vision of *what works* into their planning, and the level of departmental and institutional involvement in and commitment to reform.

A set of questions has been developed that will serve as a template for site visits to a small number of PKAL-active institutions beginning in the fall of 1996, and for a series of phone interviews with a larger number of institutions.

The results of PKAL are evident in the following ways:

* the publication of PKAL Volume III: Structures for Science–A Handbook on Planning Facilities for Undergraduate Science:
* the increasing number of institutions involved with PKAL and with similar efforts to transform undergraduate SME&T programs and of funding agencies supporting such efforts: and
* the growing network of PKAL Faculty for the 21st Century, who come with solid institutional support for their role as future leaders.

SUMMARY: Even given the level of and support for dissemination activities in recent years, there is still need for a regular and highly visible national forum which serves as a catalyst for local and national dialogue about reform. It is clear, however, that such a community is emerging. The investment over the past decade made by NSF and FIPSE toward transforming SME&T education is beginning to bear fruit. The challenge at this point is to take every opportunity to nurture it.

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REPORT TO
THE FUND FOR THE IMPROVEMENT OF POSTSECONDARY EDUCATION
FROM
PROJECT KALEIDOSCOPE

A. PROJECT OVERVIEW

The grant from the Fund for the Improvement of Postsecondary Education (U.S. Department of Education) to Project Kaleidoscope (PKAL) supported PKAL Phase II activities. In this second phase, which began in 1992, PKAL continued and built upon goals established at the beginning of PKAL Phase I, to be a catalyst for:

* reform at the local level, encouraging the strengthening of undergraduate science/mathematics programs across the country by focusing on *what works*;
* a national dialogue, one which leads to a supportive environment in which local reforms can take root and flourish.

From these two goals, PKAL developed the following Phase II aims and objectives, to:

* build campus-based teams committed to and equipped for reform;
* shape public awareness about the relationship between a strong undergraduate science/ mathematics community and our nation's leadership role in a world in which science and technology have an increasing impact on all life;
* join in partnerships with other organizations in the broad effort to transform undergraduate programs in ways that serve the national interest;
* evaluate and understand *what works* in advancing local reforms and in fostering a national dialogue.

Since Phase I began in 1989, PKAL's work has been kaleidoscopic, in that we:

* address all facets of the undergraduate science, mathematics, engineering, and technology (SMET) environment, including program and space, financing and fund-raising, recognizing that for reforms to be effective over the long-term, all the pieces must come together in a pattern that makes institutional sense;
* emphasize critical questions that must be raised about the process and the content of reform, focusing on what works (solutions), rather than what does not work (problems);
* bring all those with a stake in a strong undergraduate community to the discussions of such questions;
* promote *programs that work*, ones that can serve as models for adapting in other settings.

To achieve these goals, aims and objectives, PKAL developed a coordinated and comprehensive set of meetings, publications, and other activities–focused on fostering both local reform and national dialogue. Since Phase II began in 1992, PKAL has hosted 40 workshops/meetings, in which over 2000 individuals have been involved. One way to document the impact of PKAL is to note the number of institutions participating in multiple PKAL activities; over fifty institutions have sent individuals or teams to four or more PKAL events. Another way to illustrate the effect of PKAL is to note the increasing involvement of PKAL leaders in the work of education committees with disciplinary societies, the PKAL connections to other major efforts such as the National Research Council's Committee on Undergraduate Science, and the reference in RFP's from funding agencies about the importance of the applicants participation in significant reforms such as PKAL. (See Exhibit 1. List of workshops and participants.)

> *I venture to say that there are not a large number of institutions that, on a percentage basis, have been more active in PKAL than we have been. Not to mention myself [the dean], my office has been sending faculty to your workshops on a regular basis to the point that we are approaching 100% PKAL participation among math/science faculty, and the effect has been profound. In a period of four years, we have moved from an institution largely teaching in a conventional manner to one focused on hands-on "discovery" learning in math and the sciences to the point where I am not reluctant to say that we are a leader in our region in the*

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reformed mode of teaching. Within a very large radius of our city, I know of no other higher education institution that has the kind of commitment to this style of teaching as we do, not to mention success in implementing it.... I have little doubt that it was a factor in our receipt of a recent grant from the Howard Hughes Medical Institute.

–Dean, Centenary College

For PKAL leadership, one significant result of Phase II activities has been the achievement of a better understanding of the broader set of questions that must be addressed as institutions move through the various stages of reform. These stages move from the initial dream in the mind and heart of an individual faculty member concerned with improving the learning environment for her students, to the time when questions of institutionalizing reform (securing, allocating, and reallocating resources of time, people, and dollars to the task; how to set priorities in a collegial way; avoiding burn-out and rethinking reward systems; etc.) become the critical ones.

Another important insight from PKAL activities over the past three years is that a common stock of ideas is beginning to take hold in the broader community, instilling a sense of what it will take to build strong natural science communities nationwide that is both new, and is generalizable to many different institutions. The modes of meaningful reform need not be invented anew for very institution educating undergraduates.

B. PURPOSE

1. Problem definition–beginning of project: In the original proposal to FIPSE, we defined the problem simply. It was our conviction that although many creative and productive efforts to reform undergraduate science were beginning to emerge on individual campuses of all kinds, in all parts of the country, too often such efforts were isolated instances of success–isolated sometimes on their own campus, sometimes from the main-stream of curricular development activities, and sometimes both. This isolation (as defined in 1992) meant that as reforms were being considered:

* few faculty, administrators, and others were comfortable with going outside their normal boundaries of responsibilities and commitments to explore new possibilities/solutions based on the experiences of others;
* although many strong and creative programs were being developed, to a large extent most were having little or no impact beyond the originating institution, department, or perhaps even beyond the instigating faculty member;
* there was no regular means by which information about successful reforms could be shared with and accessed by the broader academic community nation-wide;
* there was no common stock of ideas, or vision, about *what works* in undergraduate education–either at the local or the national level; and finally,
* there was too much focus on what was wrong, not enough on tested solutions.

Our intent in PKAL Phase II was not to develop new ways of teaching and learning in the arena of undergraduate science ("science" is short-hand for "science, mathematics, engineering and technology"). It was rather to identify those who were taking the lead in developing and evaluating strong programs (*programs that work*), and to promote those programs as models to be adapted by faculty and administrators in other settings. Faculty and administrators, in large part, were the *students* targeted by our work.

There was a sense of urgency, in that it was becoming clear to us and to others within the academic community that transformation of the undergraduate environment for learning science was key to addressing a broad set of national problems: strengthening K-12 programs; fostering a scientifically-literate populace; and sustaining a well-equipped cadre of professionals in scientific and technological fields. We took as our charge the words of Robert Hutchins:

"A community must have a common aim, and the common aim of the educational community is the truth. It is not necessary that the members of the community agree with one another. It is necessary that they communicate with one another, for the basis of community is communication."

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Building natural science communities, on individual campuses and among and between campuses and organizations with similar aims, has been the reason for PKAL's existence since 1989. Although we have come to some conclusions about ***what works*** in strong undergraduate programs, our intent is not to present a blueprint for reform that must be followed faithfully, but rather to present patterns and templates for reform that–to use the kaleidoscope metaphor–can be adjusted in ways that serve colleges and universities of all sizes, with different goals and missions, students and faculty.

2. Problem definition–conclusion of project: Now, at the end of the three-year FIPSE grant to PKAL Phase II, and in the middle of a continuing series of public and private grants to PKAL, we are still convinced that communication about *programs that work* is a central problem that needs to be addressed if we as a nation are to transform undergraduate science in ways that truly serve the interests of students and of society. However, we now recognize that the problem of communication has many dimensions, with lack of time and an absence of internal and external supportive networks being two of the most intractable difficulties confronting those with the interest or inclination to explore, examine, and experiment with new approaches to improving the learning environment for their students. Other dimensions of the communications problem include:

* lack of "how-to" experience about reform
* "anti-reform" bias of current systems of recognition and rewards
* increasingly difficult fiscal environment
* lack of administrative leadership/support.

These problems are connected: the isolation of the lone-ranger change agent on a campus may result from lack of time for departmental discussions–or from the lack of administrative encouragement from deans or department chairs for such discussions. The lack of encouragement from colleagues (administrative or faculty) may be because little information is available about how peers have initiated successful reforms, or because present systems of recognition and reward within institutions and funding agencies do not make curricular reform a credible activity.

From June 1992 until August 1995, the period of FIPSE support, PKAL has hosted almost thirty workshops, seminars, and colloquia, with approximately 1800 individuals participating (many of whom have attended more than one workshop). Again and again, evaluations from participants indicate that time away with colleagues, time away from the normal routine of academic life, has been one of the most beneficial aspects of the PKAL workshop. Comments from participants include:

> "*Until this weekend, I had never had an extended discussion with my department chair.*" –Bryn Mawr Workshop
> "*...I did not know that my colleague in biology was thinking along the same lines as I...*" –Beloit Workshop
> "*We now see that reform must be a community effort, and that thus it becomes our effort to build community.*" –College of the Holy Cross Workshop
> "*It was good to have our dean with us; upcoming discussions about curricular reform will be more informed--and hopefully more productive.*" –Harvey Mudd Workshop.

The continuing comments about the value of time for discussion with colleagues, with peers from a wide range of institutions, and with leaders in the public and private arena, corroborates the effectiveness of the PKAL approach to planning meetings. They also justify our efforts for ongoing communication following each event.

What also has emerged from these workshops and the discussions they have engendered is the importance of timeliness. Timing is a critical factor as individuals and institutions seek to begin or to sustain reforms, particularly in seeking and securing funds to support such reforms. In part, this is understanding the process of reform–how to set a multi-year agenda that makes sense to both internal and external funders. "*Why is this the right action at this time for this institution*?" is a question more and more frequently asked by funding agencies and by campus leaders. This is basically a question about priorities: *"Are the right people in place? Do institutional budgets reflect changing priorities? How can this institution move from a single innovation to institution-wide transformation of SMET programs?*

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All the problems listed above are institutional ones, and we soon recognized–from responses from workshop participants, from descriptions of the PKAL Programs That Work, and from applications to and reports from the Keck/PKAL consultant teams that increasingly the issues are becoming those of how to move individual faculty and departments to think institutionally. It is vital for these constituencies to think about the relationship between changing curriculum and changing spaces, about the relationship between mission and budgets at the institutional level and at the departmental level, and how to locate local reforms in the larger context.

Other problems, such as science literacy and the international dimension of undergraduate science, proved less immediately approachable. The issues were less clear and the major players more isolated. Our approach to developing science literacy workshops was first to hold extensive planning sessions with recognized practitioners in the field, to identify the critical issues, relevant publications, etc. Although this has been more costly in terms of time and money, in the long-run we will have more effective workshops on this topic. Our first workshop on this topic was at Skidmore College in April 1996.

Finally, after several starts and stops and lack of real progress, we are beginning to develop an electronic means (gopher and World Wide Web) to communicate with the larger community. (See Exhibit 2.)

3. Administrative pitfalls to avoid: Those undertaking similar dissemination efforts must be certain to present a given reform in the largest possible context: how and why it came about, what was its impact on colleagues and institutions, what it cost, how it was funded, how evaluated, what administrative support was available, etc. Case studies should be framed as institutional stories, not stories of individual faculty or departments (as critical as they are to initiating reforms). Multiple perspectives (from faculty and administrators alike) should be brought to the case study presentations. If we had not had presidents, deans and faculty members on all PKAL committees from the beginning, our work would not have proceeded as well; if we had not taken every opportunity to build partnerships and collaborative efforts, PKAL itself may have been an isolated instance of success, rather than part of a rich tapestry of reform efforts across the country.

Another administrative pitfall to avoid by others attempting similar projects is to be certain enough staff and resources are available to develop and implement the project. PKAL has been a very lean operation, which sometimes resulted in slower than desired responses to applicants. Slowly during the grant period we learned how to use electronic means to communicate about and administer PKAL activities, and with a second major grant from NSF we have been able to add one full-time position (and one full-time temporary person). The pressure for the PKAL office has been to have an interrelated set of activities focusing on the transformation of undergraduate science, and to be honest, we never would have been able at the beginning to imagine the current scope of activities and thus to plan accordingly. But we should have been more persistent in seeking support for the administration of PKAL, and not just for specific activities.

C. BACKGROUND AND ORIGINS

1. The National Science Board Report of 1986: In 1986, the National Science Board issued a report (commonly called the Neal report) that: a) examined the current state of undergraduate science and mathematics education; and b) outlined new policies, funded programs, and funding levels necessary to build a strong undergraduate SMET community nation-wide. The Neal report was one response to the increasing recognition among the scientific and educational communities that it was at the undergraduate level that students were being lost to science and mathematics. The "champagne glass" chart, that graphically portrayed the drop-off in enrollments and interest during the first years of college, became famous, and that led to concern about whether the next generation would have sufficient science and technology professionals.

Among its many recommendations, the Neal report charged the National Science Foundation to "*gather the sense of the community*" as it went about re-establishing NSF programs that would provide specific support for undergraduate science and mathematics. Responding to this charge, in 1989 NSF provided short-term support for projects within four sectors of the higher education community–research universities, land-grant institutions, liberal arts and two-year colleges, with the mandate to each to outline an agenda for reforms in that sector. The NSF grant targeted at liberal arts colleges was the foundation for the effort that became Project Kaleidoscope; *it*

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is the only one of the four grants that has continued beyond the initial funding.

2. **The dismal state of undergraduate science (SMET) education**: The Neal report was a pivotal document. It presented and analyzed data about the present and future condition of undergraduate science and mathematics. It proposed specific NSF programs and funding levels that would begin to address in a comprehensive manner undergraduate programs that had become (to paraphrase the 1991 FCCSET report) *"...stagnant, diminished in quality, dull and uninspiring.* It was a timely document also, in that it provided a template for action for the growing number of faculty, administrators, and staff at federal and private agencies who were beginning to make tangible commitments to strengthening undergraduate programs.

The emergence of the Council on Undergraduate Research, which clearly articulated the value of (indeed the necessity of) a research-rich environment for students at the baccalaureate level, the Sloan Foundation's *New Liberal Arts* program, which focused on new uses of technologies and interdisciplinary programs, and the work of Uri Treisman on learning communities, are but some of the major efforts from the early 1980's that suggested new ways of approaching teaching and learning at the undergraduate level. The list of isolated change agents (many supported by FIPSE) was growing–including Priscilla Laws, John Rigden, John Jungck, and Lillian McDermott, in addition to Uri Treisman and Michael Doyle (CUR). These individuals were beginning to focus more intently on incorporating into the classroom new research about how the students of today learn. This was also when, in 1985 (after five years of no funding targeted for undergraduate programs) NSF announced a single program, funded at $5 million to support the acquisition of instrumentation for college science programs.

It is important to remember now in 1996 that the primary concern a decade ago was the projected shortfall by the year 2000 of new baccalaureates and doctorates in SMET fields. This led to the emphasis on research experiences for majors and potential majors, as evidenced by the influential Oberlin Report that documented the work of science-active liberal arts institutions in preparing the next generation of Ph.D's. Concerns about science for all students, and about the preparation of K-12 teachers were present, but only at the edge of the discussions. Although reforms were not yet at the level of the Sputnik-provoked reforms of the early 1960's, the Neal report struck a responsive chord in the community, particularly with science-active liberal arts colleges.

3. **PKAL Phase I**: Thus, at the time PKAL received its first grant from NSF in 1989, some solutions were beginning to be developed and implemented on individual campuses across the country, some funding agencies had set new priorities, and connections were beginning to be made–connecting an understanding of how students learn best to new approaches to shaping program and space, connecting the transformation of undergraduate programs to larger national issues (technology, under-represented groups, faculty careers, etc.). Yet there continued to be what we in the leadership of PKAL thought was an unproductive focus on *what did not work* rather than what did work. We took seriously from the beginning of PKAL the words of then Congressman Robert Roe, *"I am tired of hearing about problems. We know what works; let's move from analysis to action!"* (PKAL Volume I).

During the first Phase of PKAL (1989-1991), the members of the PKAL leadership committees (all from liberal arts colleges) looked carefully at successful undergraduate programs–those on their own campuses and on other campuses across the country. We reflected on our own experiences in classrooms, laboratories, and administrative offices, and identified the central principles that guide strong programs in science and mathematics in the nation's science-active liberal arts colleges. We did not invent or discover new practices. Instead, we documented existing practices and principles that seemed to characterize programs that were succeeding in attracting students to the study of science and mathematics, and that were ensuring their success in these fields.

PKAL provided a common stock of ideas for discussion and dialogue by the liberal arts college community. At one point during the FIPSE grant period, a FIPSE staffer told us, *"until you could make your case in twenty-five words or less, your goals were not precise enough to generate support;"* in retrospect, the PKAL statement of *what works*, although longer than twenty-five words, served as our call to action.

Drafted in 1990 in a marathon, three-day meeting involving 36 members of the PKAL leadership committee, this vision of *what works* was expanded upon in PKAL Volume I and II and presented in several Phase I meetings. Unintentionally, it set the stage for PKAL Phase II; upon reading these PKAL publications, faculty and others

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began to ask "*when are the next meetings to be? when will we have an opportunity to discuss this?*" Although other reform efforts were gaining visibility and credibility, with increasing support from private and federal funding agencies, PKAL leaders determined that our kaleidoscopic approach (addressing curriculum as well as facilities, involving faculty, presidents, and deans, addressing context as well as content of reform) was not yet taken up by others. Thus we sought support for Phase II, from FIPSE and other funding agencies, including NSF, which cooperated with FIPSE in supporting the work of PKAL.

4. Other reforms: It is important, however, in considering the background and origins of PKAL to note the many other reform movements that were beginning and that were becoming mature in the late 1980's and early 1990's. The context in which PKAL undertook its work, and in which others initiated and supported reforms, has been a growing national understanding about the role a strong undergraduate science community can play in serving the interests of students and of society. Who would have thought, a decade ago, that the National Academy of Sciences would establish a Center for Science Education? Who would have thought, a decade ago, that most of the major disciplinary societies would regularly incorporate sessions on education into their meetings? The environment for transformation–for systemic reform–is much more intellectually supportive than at the publication of the Neal Report in 1986. That this increased understanding comes at a time when funding is decreasing is a challenge indeed, but one that makes imperative the setting of clear priorities.

5. PKAL organization, policies and funding: The PKAL organizational structure and policies, established from the very beginning and continuing through Phase II, are:

- all committees include faculty and administrators, to ensure that critical perspectives about possibilities and pitfalls in the process of reform are brought to the table in the development of PKAL activities;
- as appropriate, each single activity recognizes the connections between the various components of the undergraduate environment–for example, linking curricular reform, faculty development, space modernization, administrative leadership and institutional budgeting;
- each single activity (workshops, publications, Internet, Faculty21, etc.) builds upon and leads to other PKAL activities;
- the two goals--to be a catalyst for a) informed change at the local level and b) informed dialogue at the national level– guides all PKAL planning and activities;
- the emphasis is on patterns of reform, encouraging individual institutions to determine what works best, at this time, for their students and faculty;
- volunteers are at the core of PKAL, recognizing, in a time of fiscal stringency, reform efforts must capture the imagination (time, energy, and wisdom) of a dedicated cadre of volunteers to succeed;
- the administration of the project is done primarily through electronic means; and,
- partners are sought aggressively, recognizing that "*the task is too great and the time too short*" for any single effort to be an isolated agent of change.

The search for partners extended to PKAL's effort to secure gifts and grants. The foundation of FIPSE support helped us leverage major grants–from the W.M. Keck Foundation and the Exxon Education Foundation, in addition to further NSF grants and other smaller private gifts. With this additional support, it has been possible to address more comprehensively new issues and problems as they began to surface.

6. Changes during the course of the grant: There have been several changes during the course of our FIPSE grant. One of the most visible has been to involve representatives from a wider range of institutions in the work of PKAL. Even though the core leadership comes from liberal arts institutions, as faculty at institutions of all sizes and with differing missions, in all parts of the country are beginning to wrestle with *what works*, we have brought them into PKAL leadership positions (on committees and as presenters at PKAL meetings). This was intentional, done with considerable reflection and discussion about the progress of the reform movement nationwide, as well as about the value of cross-fertilization of ideas.

Although goals stayed the same, our work during Phase II expanded to include establishing a network of faculty at the early stage of their careers (funded by the Exxon Education Foundation), consultant teams (funded by the W.M. Keck Foundation), and a more extensive program of faculty development workshops (funded by an

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additional grant from the NSF Undergraduate Faculty Enhancement Program).

D. PROJECT DESCRIPTION

1. The main features of PKAL: What we believe distinguishes our work from that of others is that we have indeed been kaleidoscopic–we have focused on the transformation of all aspects of the undergraduate environment. We sponsor, for example, workshops on facilities, because we believe that the kind of learning and teaching advocated by PKAL requires certain types of spaces (and that existing spaces were inadequate on several counts). We have put in place a program for faculty at the early stages of their careers because we recognize that it is faculty who shape curriculum, and who must "own" reforms. We encourage administrative involvement in workshop teams and in the pre- and post-workshop planning, because we are convinced that–to succeed over the long-term–reform must be a community effort. Finally, our work has been kaleidoscopic in that we have encouraged institutions to understand and relate to the larger context in which their individual efforts take place–to connect what happens on their campus to the world in which students will live and work.

Since 1992, in Phase II, PKAL has received over $2 million in grants in support of a variety of programs. As outlined in the original proposal to FIPSE, these grants supported: a) a series of national and regional workshops on issues of broad interest and concern to the undergraduate community; b) partnerships with national associations; c) a consultant network; and d) publications–print and electronic. These activities are at the core of PKAL Phase II; although not explicit in the proposal submitted to FIPSE, the PKAL Faculty for the 21st Century network brings a critical group to the PKAL effort.

PKAL *Programs That Work*. Central to the work of PKAL is identifying programs that work and bringing such efforts to the attention of the larger undergraduate community. During the course of the FIPSE grant, we have had four competitions for PKAL Programs that Work (PTW). (See Exhibit 3. for PTW Listing.) The selection process, guided by a PKAL subcommittee chaired by Jerry Mohrig of Carleton College, has become more and more rigorous over the three year period; this reflects both the larger number of competitive nominations and the increased concern within PKAL about evaluation and about comprehensive and systemic reform. The PTW subcommittee includes members of the Executive Committee, Advisory Committee and Faculty21 members. The PKAL PTW are used in the following ways:

- program descriptions are highlighted on the PKAL Gopher/PKAL WorldWideWeb;
- case studies about PTW are presented at appropriate PKAL workshops;
- faculty and administrators representing PKAL PTW are recommended when PKAL is asked for names of potential speakers/consultants/source of interesting programs; and
- those representing PKAL PTW serve as Keck/PKAL consultants.

The PTW selection committee uses the following criteria in selecting programs that work:

- innovative approaches to solving systemic problems/differing approaches to similar problems;
- innovations that could be adapted in other settings, not institution-specific; and
- innovations that were mature enough to have documented success.

It was difficult at first to generate significant enthusiasm for the work of putting together the information required by the PKAL PTW nomination process, particularly without any financial incentive. As PKAL's work became more widely known, the benefits seemed more reasonable and worth pursuing. We highlighted photos of the PTW in PKAL Volume III (see below); and many colleges and universities named by PKAL have used the citation to good advantage in college promotional and fund-raising pieces. As described below, with the Phase III focus on systemic reform, we will track the past, present, and future of selected PTW, to illustrate the process of successful reforms (including an emphasis on assessment and evaluation). Thus, *PTW* are at the core of PKAL's efforts to bring local and national communities together to wrestle with some of the critical questions and to explore solutions. Below we describe PKAL's activities toward this end.

PKAL Scientist-in-Residence. Having scientists-in-residence at regular times through the grant has been critical

to the work of PKAL, in keeping us focused on real needs of real faculty and staff, and in helping set the policies and programs for major PKAL activities. The first PKAL Scientist-in-Residence, James Gentile from Hope College, continues in a leadership role in administering the Keck/PKAL Consultant program, reviewing applications, suggesting consultants, and encouraging follow-up activity. Judy Dilts, from William Jewell College, served both a one-month stint in 1994 and a seven-month stint in 1995 as the PKAL S-I-R. During her first stay, she assisted in developing the PKAL Internet activities; during this past year she had a leadership role in organizing the expanded set of workshops supported through the NSF-UFE program. Mark Schneider, from Grinnell College, served as PKAL S-I-R and helped organize the pilot PKAL Faculty21 meeting held in Atlanta in 1994.

2. PKAL Activities: 2a) Workshops & Colloquia: During the FIPSE grant period, we have hosted 28 different facilities workshops, topical workshops, assemblies and colloquia, in all parts of the country. In total, 275 persons have served in a volunteer capacity[1] as a leader/presenter at a PKAL workshop, many for several workshops. To date (summer 1996), almost 2000 individuals have participated in one or more of these PKAL activities, representing approximately 500 different institutions. Fifty institutions have participated in four or more PKAL-sponsored activities.

Each workshop or series of workshops is planned by an advisory committee with particular expertise, working with the PKAL National Office and the local host site committee. Grant funds support the administration (promotion, registration, pre-workshop mailings), host site costs, speakers' travel, room and board, local transportation, and materials. Registration fees are set at approximately $20-30 over food charges at the site–averaging between $125-160 for a three-day event. Both the relatively modest cost and the regional nature of PKAL meetings make them feasible for a significant number of institutions.

Over the past three years, although the general workshop outline has remained constant, we have made some changes, based on evaluations from workshop participants. We now have a good structure in place, at least for the pre-workshop and workshop activities. (As described below, one of the challenges in Phase III will be to sharpen up post-workshop assignments and responsibilities.) The process for workshops is as follows:

* applications include: a letter from the president/CAO pledging institutional support for the work of the proposed team; a team statement outlining the current circumstances at the institution in regard to workshop topic (facilities, introductory courses, etc.); and biographical statements from each of the team members (why this is the right team/indicating Faculty21 (F21) member [if appropriate]);
* selection of participants is based on the makeup of the team (those with a senior administrator are given preference), the strength of the presidential support letter, and the participation of an F21 member. Most workshops are limited to 85 people;
* pre-workshop assignments vary depending on the topic to be addressed, but in all instances we expect teams to come to the workshop with some specific questions and ideas about their particular circumstances. We require posters from each of the teams. (These serve to generate discussion at the workshop and are kept by the PKAL office for future reference.); and,
* during the workshop we balance plenary sessions, small group case study presentations, and time for teams to work alone–as a team and with an assigned consultant. A final session is devoted to team presentations of their plans, with a copy left with the PKAL office.

The process for post-workshop activity is as follows:

* teams are asked to report back to their president, dean and department, and to send to the PKAL office a copy of that report, and notes on any actions resulting from that report;
* workshop presentations are placed on the PKAL World Wide Web, to facilitate continued discussions

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[1] *Those who led the three facilities workshops in 1994 were paid a modest stipend for their repeated service; most of these individuals have also presented at PKAL workshops in 1992, 1993, and 1995.*

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about questions and issues raised;
* institutions that have sent teams to PKAL workshops are eligible to apply for a Keck/PKAL Consultancy, a description of that program is below.

As the number of PKAL workshops has grown, we are developing a cadre of experienced workshop leaders, persons who understand how the PKAL workshop process is intended to work, who have both a driving commitment to *what works* and a track record as a successful change agent. We spend considerable time preparing workshop leaders, through mailings and conference calls. We ask that all workshop leaders stay for the entire workshop to serve as consultants to assigned teams in addition to making a plenary or case study presentation. (See Exhibits 5., 6., 7., & 8., for workshop-related materials.)

2b) Keck/PKAL Consultant Program: One of the most effective mechanisms that PKAL has developed to foster productive change on individual campuses is the consultant network supported by a grant from the W.M. Keck Foundation. The Keck grant supports a two-person consulting team on-site to assist in moving ahead on plans emerging from a PKAL meeting–developing a core curriculum or a program for women in science, linking planning of program and planning of space. With almost 50 Keck visits made, we are gaining a much clearer sense of how faculty and administrators are asking some basic questions about mission and priorities, in many cases taking an intentional step back to look at their entire program (a kaleidoscopic view) before moving ahead on particular reforms.

We have monitored this program carefully, and have in the office copies of:

* the original application
* the report of the consultant team
* follow-up reports from the institutions (in most, but not all, cases).

These consultancies have been extremely valuable to the institutions visited. We have received many phone calls and notes expressing gratitude from presidents, faculty members, and others for the insightful recommendations. In part, the consultancy's value derives from the fact that the visit fosters community involvement in reforms that may have been conducted in a piecemeal way before. The ripple-effect of the consultancy and involvement with PKAL often goes beyond any individual department or program. Although the assistance sought was particular to one institution and was often as specific as help for the development of an individual course or for incorporating new pedagogical approaches, some significant general points emerge as one reviews all the reports and responses. It is clear that one real issue on many campuses is the extent of the conversation about and commitment to reform. The other persisting issue is the need for a clearer understanding of the resources necessary for productive reform and for a carefully-articulated plan to set objectives to accomplish mutually agreed upon goals.

As indicated below, the materials we are assembling in the PKAL National Office in regard to reform, based on the insights and experiences of the Keck/PKAL Consultants, are an invaluable resource to the ongoing work of PKAL. Furthermore, as we analyze this material and disseminate to the larger community the results of these consultancies, the impact of the individual team visits should have a significant impact beyond a single campus. Materials relating to Keck consultancies were the core of the information used by the evaluator for PKAL Phase II. (See Exhibit 5. for materials relating to the Keck/PKAL Consultancies.)

2c) Publications/print and electronic: Since Phase II began, our focus has been on developing publications based on materials prepared for and emerging from PKAL-sponsored meetings. We have published two Occasional Papers (Attached):

* PKAL Occasional Paper #1: The Research-rich Environment
* PKAL Occasional Paper #2: Administrative Leadership and the Process of Reform.

Occasional Paper #1 captures the discussions and recommendations from a PKAL Invitational Seminar, sponsored in conjunction with the Alliance for Undergraduate Education and held at the National Academy of Sciences in February 1993. Invited to this Seminar were representatives from a wide range of private and public

funding agencies and from the nation's top public research universities, to further the PKAL goal of shaping the national dialogue. As with all PKAL activities, seminar participants worked in small groups to wrestle with some of the challenges that faculty, institutions, and funding agencies needed to address if the goal of a research-rich environment for undergraduate learners was to be achieved. Two thousand copies of this paper were distributed to presidents and deans in the PKAL data base. We have reissued the paper and copies have been distributed to F21 members and are being used at PKAL workshops that continue to address this topic.

Occasional Paper #2 includes presentations and follow-up comments from the PKAL Invitational Meeting at Trinity University in January 1994. This was the first PKAL activity focused primarily on administrative issues, and materials from this Seminar have set the stage for subsequent discussions about administrative roles in other PKAL meetings. This seminar was one of the more frustrating hosted by PKAL, in that an ice storm delayed or detained speakers and participants and required much juggling of the schedule. However, having Dr. Bruce Alberts on phone hook-up, although not as good as in person, suggested ways to use audio-visual connections in future PKAL events.

Increasingly, PKAL has been distributing materials by electronic means, putting workshop presentations and other relevant essays and comments onto the PKAL Internet Link. It has only been in the past year that we are beginning to realize the potential of means such as the gopher and the World Wide Web for the purposes of building and sustaining dialogue on critical issues--at the local and national level.

As PKAL has matured, much more interesting and unique material has become available that we can share with the larger community. In organizing the 1995 set of PKAL Workshops, we have been able to capture many more of the presentations in a form that works for electronic distribution. We are currently contracted with a firm to assist in the graphic and structural development of the PKAL World Wide Web pages, particularly highlighting the PKAL Faculty21 network.

2d) Facilities Workshops and Publications: The major publication of PKAL Phase II is Volume III of the PKAL reports: *Structures of Science--A Handbook on Planning Facilities for Natural Science Communities.* This 250-page report incorporates materials developed for and arising out of the eight workshops on facilities planning that PKAL has hosted since 1992. One copy of Volume III was sent earlier to the FIPSE Office.

The bridge between PKAL Phase I and Phase II was the beginning of a series of workshops on facilities. These workshops built on issues raised in Volume I of PKAL reports, in which we addressed the relationship between spaces and programs that work. It was our sense that the needed transformation of undergraduate SMET programs could not be effected without spaces that supported such reforms. Since 1992, PKAL has hosted ten workshops, colloquia, and seminars focused on facility planning, with 225 institutions participating. An estimate of anticipated project costs on those campuses is nearly $2 billion. PKAL's activities in regard to facilities have been significant in our progress toward achieving goals set for Phase II--*to be a catalyst for local reform and for an informed national dialogue.*

Two 1995 facilities meetings have been held in Washington, DC. The first, in February 1995 at the National Academy of Sciences, included presentations by representatives of NSF and several private foundations; by Dr. Bruce Alberts, President of the National Academy of Sciences; and by the Honorable Robert Walker, Chairman of the Committee on Science, U.S. House of Representatives. In December 1995, at the occasion of the publication of PKAL Volume III, we hosted a seminar on facilities in conjunction with the American Institute of Architects. In large part, the current generation of spaces and structures used for undergraduate programs was constructed in the early 1960's, when the country's response to Sputnik led to the development of facilities and new programs that would attract more of the brightest and best to the study of science. Those spaces are deteriorating and do not meet current codes; they also do not accommodate the kind of undergraduate environment for learning that is now the goal of many institutions. These issues, which were laid out in a background paper by Daniel Sullivan (President--St. Lawrence University and Chair of the PKAL Executive Committee), were considered in depth at the December Seminar and will be considered in greater depth by PKAL in coming months.

Facilities workshops attracted a wider range of institutions to PKAL. That is significant, but more important is

that on many campuses, participation in facilities workshops seems to have a spill-over effect on curriculum planning and institutional strategic planning. Many institutions that made an initial PKAL connection through facilities have continued to send teams to PKAL meetings focused on curricular matters, and/or have applied for a Keck/PKAL consultant team. It is clear that our challenge to institutions is that they must consider the larger context. This is true for any foundational reform, and particularly those that entail the renewal of space, which is costly and "cast in concrete".

> *I write to let you know how important PKAL activities have been to our conceptualizations about science education and science facilities. About five years ago, Hartwick College almost built a new science facility. Although decidedly needed, had we done so, it would have been the wrong kind of facility. We know that because of the changes in our thinking about sciences and facilities, perspectives that have been heavily influenced by PKAL....Attendance at an early facilities meeting challenged us to think about the educational program before facilities planning. The month before I began my position here, I attended the PKAL meeting at Bryn Mawr with two faculty whom I met there for the first time. It gave me the opportunity to understand some of the issues I would face here, and initiated an image of me as a Dean who cared about the sciences. As individual faculty have continued to attend discipline-specific and interdisciplinary PKAL workshops, we have shaped the educational program. And the selection of two of our faculty as "Faculty 21" has given them the external validation to convince colleagues that their approaches to the teaching of sciences are indeed more effective methods. Perhaps the best way of expressing our thanks is to say that I cannot imagine having come this far without the support of PKAL!*
>
> – Vice President and Dean of Academic Affairs, Hartwick College

In PKAL Volume III: *Structures for Science* we have emphasized both the local and national context in which facilities planning must occur, capturing much of the material and discussions from the various facilities workshops. Volume III also includes ideas and essays that have emerged from other PKAL meetings and from Keck/PKAL consultant reports, as well as contributions from a wide range of persons with experience in all areas of facilities design and planning. To a large extent, Volume III both serves as a summary to PKAL Phase II and sets the stage for Phase III; it follows the expected PKAL approach in that it focuses on all the facets (mission, curriculum, teaching styles, etc.) that must be considered if the environment for student learning is to be improved. It also brings perspectives from the various members of the community (faculty, presidents, deans, trustees, etc.) who must have a leadership role if transformation of space and program are to happen.

One particularly rewarding dimension of PKAL's facilities activities has been the opportunity to assist institutions in preparing competitive proposals to the NSF Academic Research Infrastructure Program (and to other funding agencies). At the request and with the support of NSF we coordinated a series of seminars and workshops focused primarily on assisting institutions in writing proposals for NSF and private funding sources. One outcome (anticipated!) of these seminars was an increase in proposals to the NSF-ARI program, from 32 to 92 in one year.

2e) Faculty21: Significant and long-lasting reform begins with the science faculty and is sustained by them, and we have begun the process of establishing a network of faculty who will be leaders in science education in the twenty-first century. The network began as a pilot project in October 1994 when 150 faculty, selected by their deans or department chairs, attended a PKAL National Assembly in Atlanta that focused on science careers. As a result of that meeting, the Exxon Education Foundation supported a program that will continue until the year 2000, through which we will identify and support approximately 1,000 undergraduate faculty leaders in science education. They are and will be faculty members who have demonstrated an ability in the classroom as energetic, innovative teachers, a commitment to integrating research and teaching, and who have the institutional support necessary to be effective change agents.

Faculty at all stages of their careers are critical to our endeavor. But clearly the faculty members we will look to in order to sustain reform well into the twenty-first century are those currently in the early stages of their careers. Therefore each year, PKAL asks undergraduate institutions across the country to identify and nominate such faculty members, those who have demonstrated the promise that will enable them to advance the process of reform in science at the local level, and to shape the national dialogue about the role of strong undergraduate programs in serving society. Each year PKAL elects approximately 150 new faculty members to the ranks of

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Faculty21; thus at the PKAL F21 National Assembly to be held in Kansas City in October 1996, we expect a gathering of 400. There are currently 250 Faculty21 members – a selection process for the next class is currently underway, with nominations in hand from almost 200 institutions.

The following quotes from nomination letters illustrate the level of institutional commitment to identifying and nurturing exemplary science faculty members:

> *"On our campus we are creating a climate for building and sustaining momentum in science education reform; just this spring our faculty voted to approve a program in secondary teacher certification, and I envisage my nominee's leadership will be crucial in attracting our students who are concentrating in science to prepare for secondary school teaching."*

> *"One of the persisting questions I wrestle with as a dean is, 'What will the college look like, and who will lead it, a decade or two from now-- into the next century?' Our nominee has expansive and lively interests, and I will be more than pleased to retire (not just yet) and leave this place in the hands of people like him."*

> *"Perhaps one of her strongest assets is her willingness to explore and employ more effective pedagogical approaches in order to convey to students the inherent values and excitement in the subject matter of chemistry. Her exercises in science have been extremely well-received by faculty from across the university, and thus she has been a key factor in building bridges between departments--which is a critical need at this time on our campus."*

Although we recognize that reform happens in incremental stages, engineered by dedicated faculty within their own institutions, reform is more likely to happen when faculty have persisting opportunities to exchange ideas and experiences with colleagues across the country who are dedicated to the same goals. PKAL Faculty21 sponsors a number of activities aimed at supporting just such an ongoing exchange:

* Annual meetings. The annual National F21 Assembly is a unique event that brings the Faculty Scholars together with experienced reformers and national leaders from many disciplines and from all sectors of higher education. It serves as a forum of *What Works*, and provides an opportunity to discuss ways in which to shape a productive career in challenging times. The first such meeting was held in Atlanta, as noted above, in October 1994. The second meeting, held in Minneapolis in November 1995, addressed the question, "What do all students need to know about the disciplines of natural science and mathematics before they graduate?" The third meeting, to be held in Kansas City in October 1996, is entitled, "Exploration and Discovery: Scholars and Leaders," and will have as its principal guest Dr. Bruce Alberts, President of the National Academy of Sciences.
* Regional gatherings. PKAL F21 members hold regional gatherings at all of the PKAL Workshops, as well as participating often as leaders in the workshops.
* The PKAL F21 Dean's Dialogue. We have established an Internet conversation among F21 deans and department chairs, a conversation that includes speakers and leaders at the F21 National Assemblies and members of the PKAL Leadership Committees. The Internet link affords opportunities for F21 Faculty to build connections to shape careers by encouraging partnerships with colleagues across the country. It also helps them meet the responsibility faculty members assume when they become an F21 member – to keep PKAL and other F21 faculty informed of successful innovations in teaching science and mathematics to undergraduates, and to keep his or her community informed about PKAL activities and about what works at other institutions.

The work of a change agent can be frustrated by departments' resistance to change, by limited facilities and equipment, by isolation from disciplinary colleagues at other institutions, and by the pressures of integrating her or his professional and personal life. The benefit of a support network of peers is evident from reports from F21 members of the class of 1994:

> *"The PKAL F21 network has given me the support and courage I needed to attempt to bring a change in the way we teach physics here. Last year's PKAL meeting showed me that there are a lot of people interested in change, and that a lot us were facing similar challenges."*

"The PKAL F21 network gave me contacts who have assisted us as we plan for the renovation of our science building. I had the opportunity to visit a new science building as a result of a contact in my F21 group last year."

"Last year's PKAL meeting provided me with encouragement to try harder to integrate teaching and research. I also learned that it is possible to change introductory biology courses radically."

With the metaphor of the kaleidoscope, PKAL signals that such goals can only be achieved in partnership with many others – organizations and individuals with a common commitment to achieve a lasting transformation of undergraduate science. PKAL's progress in achieving the above goals can be documented in part by identifying the extent and character of the connections made to this point in PKAL Phase II. I say "to this point" because it takes considerable time to develop productive connections, to identify potential partnerships with mutual interests and establish credibility to encourage and facilitate partnerships. The reason for making such connections is, in the words of the Honorable George Brown at the 1991 PKAL National Colloquium: *"We must collaborate. The time is too short and the task too great to do otherwise."*

The opportunity to learn from and work with like-minded colleagues is of great value to the work of PKAL and to the larger reform movement. Also, the more opportunities PKAL has to engage others in dialogue about critical issues will hopefully lead to more creative and effective reforms in a variety of arenas, in developing and implementing them–as well as evaluating their effectiveness.

E. EVALUATION/PROJECT RESULTS.

Evaluation of the work of PKAL takes place on several levels: at the time of individual workshops/meetings; assessing the breadth and depth of the national dialogue about *what works* in undergraduate science; and determining what works in building and sustaining strong learning communities on individual campuses. As described below, evaluating single PKAL activities has been relatively simple; it also has not been too difficult to determine the impact of PKAL on the national dialogue. The greater challenge has been to monitor in a formal way the impact of PKAL participation at the local level. What we have done in this regard is to:

* send surveys out to a selected number of PKAL presidents, with follow-up surveys to some faculty and administrators on their campuses. These surveys gave us some base-line information about the presence of PKAL and the way PKAL information was being distributed and used;
* institute a regular series of questionnaires to secure information about institutional planning from institutions participating in PKAL facilities workshops. This information, which suggested changes in workshop format and direction for the development of Volume III, was gathered and analyzed by an evaluator supported by the NSF Facilities Workshop grant;
* have a selected number of institutional files analyzed by Dr. Elaine Seymour, Department of Ethnography at the University of Colorado/Boulder.

Given the inter-relationship of the various PKAL activities–particularly the workshops, Keck/PKAL consultancies, and the F21 network, it is becoming easier to document how involvement with PKAL is changing the institutional culture. The difficulty is primarily one of timing: it takes time for the ideas and insights generated by participation in a PKAL event to take root and flourish. It is also essential to have a critical mass of people committed to action toward reform.

The words of Parker Palmer (Change–1992) about the stages of reform (moving from the actions of a single change agent, to that of small groups of like-minded people, to the stage of a movement–and then finally to the point where systems and structures have been transformed) fit the PKAL experience. From the beginning of Phase I, we have identified single change agents (isolated instances of success–*programs that work)* and built a larger and larger company of individuals and institutions taking action to explore and implement similar reforms. During Phase II, we have gathered an extraordinarily rich archive of materials from and about the 500 institutions that are at some stage in the process of reform–materials which document that a movement is indeed developing. These materials include applications to and reports from workshops, applications for and reports from Keck/PKAL Consultants Teams, nominations for and reports from the PKAL F21 members. We have

expended considerable energy in reviewing these materials (see below), and believe that the time is now right to complete the evaluation of the impact of PKAL at the local level.

1. Workshops: Each workshop/meeting is evaluated by participants and leaders before leaving the host site. The comments on the individual responses play a significant role in determining how the work of the PKAL office is structured, how workshops/meetings are promoted and organized, and how we continue with follow-up activities. The most persistent early comment was the lack of opportunity for hands-on explorations of the new pedagogies and technologies being presented in the sessions. We have responded to this critique and are now better at incorporating active learning into workshops. These evaluations also help in identifying speakers to have as "repeaters". A template for all PKAL workshops (for Phase III) has been developed, and having this template will facilitate planning, working with committees, presenters, and host sites coordinators. (See Exhibit 4. for workshop-related materials).

2. Project Goals: The impact of PKAL can be determined from a consideration of our original goals, to be a catalyst for:

* broadening the dialogue about the role of a strong undergraduate science community in the service of the nation; and
* encouraging and sustaining reform at the local level.

2.a) National Impact. Our impact on the national scene can be documented in several ways. At the June 1996 NSF Invitational, PKAL was cited publicly in several presentations as the catalyst for reform on an individual campus; similar comments were made at the 1996 Conference of the Council on Undergraduate Research. Jeanne Narum, PKAL-Director, was invited to write a paper on *"New Spaces Needed for Undergraduate Science"* for "Issues in Science & Technology," the publication of the National Academy of Sciences, and to prepare a chapter for a book (to be published this fall) on "Student-active Learning," describing a decade of reforms in undergraduate science from the PKAL perspective.

As a means to broaden the national dialogue, PKAL has invited presidents/senior officers from the American Chemical Society, the American Association of Physics Teachers, and Faculty in Undergraduate Neuroscience (among others) to participate in PKAL workshops, and has connected to educational activities sponsored by various disciplinary societies, including:

* American Cell Biologists
* Association of Comparative and Integrative Biology
* Association of Physics Teachers
* National Association of Independent Colleges and Universities
* Biennial Conference on Chemical Education
* American Association of Mathematics Teachers of Community Colleges
* American Mathematical Association.

In like manner, we have involved representatives from a wide variety of public and private foundations in PKAL activities. Participants have been invited at national meetings and speakers and panelists at regional workshops. Such invitations have the dual purpose of encouraging continued and open discussion about issues of mutual concern, and alerting funding agencies to some of the critical needs and opportunities within the larger undergraduate community, thus helping to shape their agenda.

In practice this means that several funding agencies have begun encouraging potential grantees to become involved in PKAL activities. The most explicit illustration of this is the RFP issued by the Sherman Fairchild Foundation, which asked the invited applicants to reference PKAL connections. Institutions have made contact with PKAL at the direct recommendation of both the Whitaker Foundation and the F.W. Olin Foundation. Staff from the W.M. Keck Foundation and the Camille and Henry Dreyfus Foundation, Inc. have been the most active 'intelligence brokers' for PKAL within the higher education community, alerting us to programs of particular strength. In exploring new directions for programmatic support, a trustee from the Murdoch Trust made a visit to the PKAL National Office. The Exxon Education Foundation staff had extended conversations

during 1993-94 about the scope and future of educational reform in the context of re-initiating programs at Exxon.

Informal reports from NSF review panels indicate that a significant percentage of proposals for instructional equipment acquisition and/or for curricular reform cite either PKAL involvement or suggest the applicant is working toward the PKAL vision of *what works*. With the recently-initiated NSF Chemistry Initiative (focused on transforming introductory courses), NSF staff suggested to some final applicants that PKAL could serve as the dissemination vehicle, and indeed, several of the NSF Initiative projects have been spotlighted in workshops on chemistry reform.

Several national publications have mentioned PKAL activities during the past few years, including "The Washington Post", and "Science" (issues on undergraduate reform and on diversity in science). The NSF has highlighted PKAL in several publications for the larger community, including a story that tracked the development of a major initiative in undergraduate chemistry headquartered at Beloit College to the experience that the PI, Brock Spencer, had at the first PKAL National Colloquium in 1991!

2.b. Local impact: Addressing our goal of equipping institutional teams for leadership in local reform efforts begins at the point of applying for a specific PKAL activity. The PKAL archive on reform serves as the foundation for the more formal and extensive evaluation of the work of PKAL. The process of distilling insights and helpful information from the expanding institutional files has begun. Dr. Elaine Seymour, Department of Ethnology, University of Colorado/Boulder, reviewed a selected set of institutional files, ranging from institutions which had attended only a single workshop and to others at deeper levels of involvement and those who have received Keck visits. Her review (done with the assistance of a graduate student), took most of 1995, working on a part-time basis. The results of their work (see Exhibit 6. for report from Dr. Seymour), is now in the hands of the PKAL National Office.

One critical aspect of her evaluation was of the Keck/PKAL Consultant Program, about which she reported:

> *It is clear that all of the Keck consultants understand Project Kaleidoscope's philosophy of curriculum and pedagogical reform, and--in selected cases--the relationship between such reform and the development and/or renovation of science facilities. The Keck reports also reflect that the Keck/PKAL consultants have promoted the PKAL vision of what works during the site visits. This is evident from their persistent focus on encouraging inter-campus discussion and cooperation on critical issues of mutual concern.*
>
> *Predominant among recommendations made were: encouraging the examination of mission statements and the development of specific, workable, and visionary campus master plans and curricular strategic plans; linking curricular planning to facilities planning; stressing student-faculty research and interaction; and supporting a wide variety of initiatives for faculty professional growth. Generally the reports are informative and relevant. Their suggestions and recommendations reflect genuine consideration and support for the faculty, departments and institutions with whom they consulted; they emphasize the distinctive strengths and challenges of their assigned institutions.*
>
> *The consultants come as educators who are in the position of assessor and advisor. Institutions request a Keck consultancy as a means to affirm or revise the institutional self-analysis of current problems and strengths and to seek advice on specific next steps in the process of reform, given the identified problems and strengths. The individual reports are valuable to the visited institutions as catalysts for the reform of local programs, as a source of ammunition for those who are already persuaded and as motivation to those who need to be persuaded.*

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Dr. Seymour also analyzed files from about 15 of the institutions that had various stages of involvement of PKAL (when she began her work in the summer of 1995). She and her colleagues began with a list of criteria for success on individual campuses, including:

* their vision of what works;
* the extent of departmental and institutional plans in place/developing that focus on translating that vision into action;
* have a good sense of who their students are;
* are making internal and external connections in the process of implementing reforms; and
* the character of individual faculty development plans.

From their analysis based on these criteria, Seymour and her colleagues developed an extensive set of questions to be used in the process of phone contacts and site visits. (See Exhibit 6. for materials from the Seymour analysis.) Dr. Seymour's work sets the stage for more extended evaluation activities in the 1996-97 academic year. The subcommittee on evaluation chaired by Daniel Sullivan (Chair–PKAL Executive Committee) has identified colleges and universities with different levels of PKAL activity and, using the questions and issues outlined by Dr. Seymour, is developing a template for on-site interviews. Institutions to be contacted will be: Drury College; Spelman College; Middle Tennessee State University; University of Michigan/Dearborn; and Assumption College. This first group is highly PKAL-active, giving us an opportunity to identify and assess how local communities of reform emerge from the work of single change agents or small groups of reformers. These interviews will be conducted by phone and through site visits by the Committee of Visitors during the coming academic year.

The Committee of Visitors includes Dr. Thomas Cole, President–Clark Atlanta University, Neil Grabois, President–Colgate University, Lynn Steen, Professor–St. Olaf College, Michael Nelson, Dean of Science–Truman State University, Laura Parmentier–Professor–Beloit College, Laura Hoopes, Dean–Pomona College. Interviews and visits will be coordinated by Julie Monson (former member: PKAL Leadership Committee/PKAL Committee of Visitors). A second series of site visits will be scheduled during the summer of 1998 (with reports integrated into the development of Volume IV). A visitor "training session" is scheduled for the early fall 1996. In addition to these site visits, we will identify a larger number of institutions, including colleges and universities with PKAL PTW, those who have hosted a Keck/PKAL Consultant team, and those with a number of PKAL F21 members and conduct a coordinated series of phone interviews with selected staff.

From the phone interviews, site visits, and other PKAL activities we will gain a better sense of the long-term impact of different ways of approaching faculty and curriculum development, surveying how diverse approaches work in various settings. What we are ultimately evaluating in the work of PKAL is our progress toward addressing the problem and achieving the goals identified for the project. To consider progress toward the goal to have an impact on a significant number of colleges and universities and to encourage and support comprehensive reform at the institutional level–we need to ask the questions identified by Dr. Seymour, such as:

* *has involvement in PKAL made a difference at the institutional level, are new pedagogies being used, has the curriculum content been evaluated and reshaped (as appropriate), has the institutional/departmental mission statement been revisited, are new approaches to recognition and reward of faculty being considered, etc.*

These are the questions to be pursued by the Site Visitors and the Keck/PKAL Consultants. We are in the process of expanding the questions to be addressed by teams applying for the workshops, to gather valuable information about current reforms, about institutional assessment efforts, etc., that will allow better tracking about the progress of teams and institutions participating in PKAL. The current set of F21 nominations includes many from deans with significant involvement with PKAL, and those statements (which will be summarized in a publication for the fall assembly) point to the cumulative benefit of PKAL involvement. They will be reviewed by the PKAL evaluators, as well as by those evaluating F21 network activities.

Exploring the issues and questions identified by Dr. Seymour, by the Keck/PKAL consultants, and by the PKAL Committee of Visitors that are being addressed by *institutions that work* is important to evaluate the present impact of PKAL. More important, understanding better how institutions (faculty and administrators) respond to the challenges of reform will help clarify some larger questions about the future of the process of reform and the impact of networks, of initiating and sustaining connections within and beyond immediate colleagues and friends.

There are several other, less formal, ways to determine the impact on participating institutions. One is to note the repeaters in workshop participation, with over fifty institutions having attended four or more workshops. From application materials, we know some institutions are budgeting for PKAL attendance and for follow-up activities in their institutional budgets. Another sign of the local impact of PKAL is the growing number of queries about a possible PKAL-connection to anticipated meetings on their campus, particularly in regard to the dedication of new facilities. In our recent request to NSF for support for Phase III workshops , we cited a significant number of institutions that have asked to host a meeting, for example, the City University of New York/City College wishes to host a PKAL event focused on Urban and Commuter Universities during their anniversary year in 1997. Institutions obviously feel secure that the PKAL connection makes sense and is beneficial to the entire institution. (Further examples can be seen in recent correspondence from participating PKAL school officials. Exhibit 7.)

Also, a significant number of institutions, in the process of developing proposals for external support, ask for a PKAL letter of commitment to attach to the proposal (including a recently- funded FIPSE-project at the University of Richmond). One of my personal "best things" is a request to write a letter for the tenure file for an F21 member at a major research university. (She got tenure!)

> *"Attached is a nomination for .... for the PKAL F21 Class of '96. We will now have three F21 members. As a side note, the Division of Science now has a "formal" PKAL committee composed of Osborn, Tanenbaum, Moody, Delawrd, Freeman, Sanders, and Nelson (all PKAL participants) that meets twice a month to share ideas gleaned from previous meetings. The committee will act as a "think tank," as a solicitor of ideas, as an information source, and as an agent of change."*
>
> – Dean, Truman State University

Eight thousand copies of the 1996 Report on Project Kaleidoscope have been distributed. Some of these were sent out to individuals (presidents, deans, workshop presenters, etc.); but a large group were sent out to a single person on a campus, with a request that the reports be distributed and used as the basis for discussion within the campus community. (Exhibit 8. PKAL Report) Along with copies of the Report we sent out a listing of institutional involvement with PKAL–a list that will be helpful both at the local level and for the continuing work of PKAL. (See Exhibit 9. for institutional report example.)

Our goals of affecting the national dialogue and facilitating change at the local level are closely linked. Our facilities effort has brought concerns about new spaces that accommodate new programs to the attention of a wide range of design professionals and potential funders, as well as colleges and universities. (Since 12/95, almost 600 Volume III copies have been distributed.) This impact has been carefully documented and evaluated, and that material will also be valuable as we assess the larger impact of PKAL. Also, it is clear from conversations with foundation officials, that they are responding with tangible and intangible support for faculty and administrators who are implementing innovations that work and for institutions that are making the cultural changes that encourage such activity.

IV. SUMMARY

The PKAL network within the undergraduate SME&T community is growing; it includes many institutions where undergraduate faculty are actively and creatively incorporating new content, instrumentation, and pedagogical techniques into their classrooms and labs. We are planning to continue our many efforts to engage this community in productive dialogue about *what works*, and to help individuals and institutions in translating that vision into action within their particular environment. We have submitted a major request to NSF for continuation of the PKAL workshop series. We have just received announcement of a second Keck grant, so the

Keck/PKAL Consultant Program will continue through 1999; the support from Exxon for the PKAL Faculty21 continues to mid-1998, so we have a firm foundation from which to plan for the future.

Our aim is to challenge participating institutions to understand the new kinds of connections that need to be made and sustained--between colleagues with different responsibilities and expertise on a single campus, between disciplines and sectors of higher education, and between higher education and other partners--the K-12, business and industry communities--if reforms are to have long-life. Even given the level of and support for dissemination activities in recent years, there is still need for a regular and highly visible national forum which serves as a catalyst for local and national dialogue about reform, a dialogue about educational issues comparable to that within the research community about issues of science and technology. Such a community is emerging. The investment over the past decade made by NSF and FIPSE toward transforming SME&T education is beginning to bear fruit. The challenge at this point is to take every opportunity to nurture it.

With support from NSF and private funding agencies (proposals submitted) PKAL Phase III Workshops fit into the larger goals of PKAL, to provide a continuing forum for the brokering of intelligence about *what works* in building natural science communities in undergraduate colleges and universities, and in transforming institutions so that such communities can flourish. This dialogue is also directed toward the goal of gaining a communal understanding of and respect for strong undergraduate SME&T programs, in the context of ensuring that students lead productive and self-fulfilled lives and that the nation is well-served by the next generation of leaders.

> *It is important to the vitality of teaching in mathematics, science and engineering, therefore, that the best of new programs become known, and seriously considered for adaption, where appropriate, for use at other institutions. Faculty in other departments and at other institutions must learn about the best of the innovations and must have access to the financial and human resources needed to evaluate and adapt worthy ideas to other settings.* --NSF Report, 1992.

In addition to continuing existing activities, one aim for the coming phase will be to develop a greater presence on the World Wide Web, with the hope that by 1999 the PKAL site will be recognized as one of the major 'intelligence-brokers' about successful efforts to transform undergraduate science. We will use materials prepared for and emerging from workshops, from the Keck/PKAL Consultancies, and from activities related to the F21 Network to develop this resource. The evolution of PKAL World Wide Web will be monitored to assess how scholars access and use what we produce and, as with all PKAL activities, changes will be made in response to those evaluations.

Another aim for Phase III is to develop the next volume in the series of PKAL reports. Volume IV, presently titled: *"Patterns of Reform:Institutions that Work "* will be comparable to Volume III, in that it will include case studies of institutions exploring and evaluating new approaches to learning and teaching on their campus, essays and presentations from the various PKAL workshops and meetings that will be held in 1997-99 (and from Phase II workshops). An analysis of Keck/PKAL Consultant reports and materials from the Committee of Visitors will also be incorporated into Volume IV, which is scheduled for publication in 1999.

It is interesting to reflect upon how different the environment for reform is from 1992, when PKAL Phase II began, and--even more striking--since 1989 when PKAL began. It has been harder than anticipated to eliminate the "not-invented-here" syndrome that affects higher education and impedes the process of reform. Although faculty of all ages are on either side of the "why not" – "no never" approach to reform, the most significant intentional negative responses come from older faculty--who comment "I've seen reforms come and go...I will wait this one out also." It is clear that without real support from senior administrators, substantive reforms will not take place and institutions will never be able to move into Palmer's third phase of reform.

With the people, systems and structures now in place, PKAL is poised to pursue these goals, to build regional and national networks of individuals and institutions committed to and working together to incorporate best practices into their processes of faculty and curriculum development, institutional budgeting and planning. This will take serious conversations: about the inter-relatedness of education and research; about assessing the progress of institutional reform; and about ensuring the success of all students.

Why is this critical? The words of Lewis Thomas used at the very beginning of PKAL *Volume III–Structures for Science* give one answer to this question:

> *An appreciation of what is happening in science today, and of how great a distance lies ahead for exploring, ought to be one of the rewards of a liberal arts education. It ought to be a good in itself, not something to be acquired on the way to a professional career but part of the cast of thought needed for getting into the kind of century that is now just down the road. Part of the intellectual equipment of an educated person, however his or her time is to be spent, ought to be a feel for the queernesses of nature, the inexplicable things....And maybe.....the scientists might discover in it a new and subversive technique for catching the attention of students driven by curiosity, delighted and surprised to learn that science is..."an endless frontier." It is worth a try.*
>
> –Lewis Thomas. Late Night Thoughts on Listening to Mahler's Ninth Symphony